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HIGHWAY ENGINEERING EDUCATIONAL PROGRAMS AND PROBLEMS

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HIGHWAY ENGINEERING EDUCATIONAL PROGRAMS AND PROBLEMS

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In recent months nation-wide attention has been directed through the press, radio and television to the seriousness of the highway situation. The nature of the situation was ably summarized by President Eisenhower, in the following statement, made just prior to his inauguration:

"The obsolescence of the nation's highways presents an appalling problem of waste, danger and death.

"Next to manufacturing of the most modern implements of war as a guarantee of peace through strength, a network of modern roads is as necessary to defense as it is to our National economy and personal safety.

"We have fallen far behind in this task - until today there is hardly a city of any size without almost hopeless congestion within its boundaries and stalled traffic blocking roads leading beyond these boundaries."

The President stated that a solution can and will be found through the joint planning of the Federal, state and local governments.

There are many factors which have contributed to the seriousness of our present predicament; among them are the following: (1) vehicle registration and usage have skyrocketed since the end of World War II overcrowding our highways beyond all expectations, (2) unusual population growth and increasing decentralization in urban areas have contributed to daily traffic jams in our cities and towns, (3) inflation has cut the highway dollar in half, (4) wartime neglect has contributed to rapid deterioration of roads, (5) there has been a shortage of trained engineering personnel. Additionally, in many of the states, the existence of the following conditions has compounded the difficulties of providing adequate highway systems: (1) legislative bodies and public officials have not been responsive to highway needs and have not provided the necessary legislation to finance urgently needed highway improvements, (2) there has been excessive diversion and dispersion of highway funds, and (3) employment in some highway departments is relatively unattractive to professionally trained engineers, the pay has been poor, and political influences have unduly affected appointments and promotions as well as technical operations.

It is not our purpose here to place blame for the present critical highway situation on particular agencies, organizations, and professions. Highway transportation and the nation's traffic problems are so intimately interwoven with the daily activities of all our people as to make highways and traffic the responsibility of many public and private agencies, organizations, and professions. As might be expected with so great a division of responsibility, certain important phases of highway engineering have suffered from lack of coor-

dinated attention and planning. One of these phases, -- the acquisition, education and professional development of personnel -- is particularly in need of attention at the present time.

Highway and traffic engineering are important segments of civil engineering and, as such, a major responsibility for solving highway and traffic problems has been placed upon civil engineers and, consequently a share of responsibility also falls upon the engineering educators and research staffs of the colleges. Practicing civil engineers, educators and research staffs have contributed in countless ways to improve highway transportation during the past 50 years, but there is considerable evidence that, as President Eisenhower reminds us, "we have fallen far behind in our tasks". Furthermore, the highway and traffic problems are becoming increasingly complex and their solution presents an even greater challenge than at any time in the past.

In recent years some state universities such as Purdue, Illinois, Virginia, Florida, Kentucky, and California have recognized the need for broader and more intensive highway engineering education programs to meet the challenge created by the present critical traffic situation. Some unusual programs have been introduced at these universities in which emphasis is given to basic training, graduate work, research, improvement of the professional status of the highway engineer by various types of extra-mural training programs, and to cooperation with Federal, state and local highway agencies in the performance of these functions.

In this paper we propose to discuss various phases of the new programs which are being developed. There are, however, some critical problems in engineering education against which these new programs must be viewed. We shall discuss these first, along with the important factors which have had much to do in shaping the pattern of engineering education today.

Critical Problems In Engineering Education

Many engineering educators are alarmed about the present shortage of engineers, the greater shortage in prospect, and the increasing demands for the engineers' services brought about by the rapid advances in science and technology. Also there is great concern as to whether our present programs of engineering education will satisfy future demands for engineers. It should be recognized that engineering progress will depend in large measure on the engineering education program of today and on the extent to which promising high school graduates can be attracted to the study of engineering.

Present world conditions greatly complicate the planning of long-range programs in engineering education. While this may contribute to uncertainty in such programs, it also accentuates the need for planning such programs.

Dean S. C. Hollister of the College of Engineering, Cornell University, in his presidential address at the American Society for Engineering Education Convention in June 1952, clearly set forth the need for a study of the engineering profession and of the engineering education program, in view of the present and future shortage of engineers. The increasing demands for engineering services in our modern economy accentuates the need for appraisal now. Dean Hollister reported that recent surveys indicated the present need for engineers to be of the order of 80,000 whereas the number of engineering graduates for this year and for several coming years is 20,000 or less per year. Furthermore, under the present military program, more than half of the engineering graduates may be called into military service for at least 2 or 3 years, thereby postponing their availability for service in engineering practice. Assuming that the present international situation will persist for

many years, it is evident that the present shortage of engineers will also continue for some time to come.

Even if the international situation improves, thereby reducing the number of engineers called into military service, there still remains the continually increasing need for engineers under the rapidly accelerating technological development of the present era. The following statistics are significant. According to the census, in 1890 there was one engineer to about 300 workmen employed in industry; today there is one engineer to about 50 workmen employed in industry. Dean Hollister pointed out that "this trend cannot continue since the number of freshmen normally entering engineering is a fixed percentage of the age population and this percentage is not likely to increase. Thus the increase of engineers as a percent of the population has reached a stopping point".

The nation is, therefore, confronted with an increasing demand for engineers with relatively fewer engineers from year to year to meet these demands. This situation is almost certain to require a revision of objectives in engineering education, a possible reorganization of the professional function and a revision of engineering curricula.

Last year Dean Hollister appointed a new ASEE Committee on Evaluation of Engineering Education with Dean L. E. Grinter, Dean of the Graduate School and Director of Research, University of Florida, as Chairman. This committee is organized on a nationwide basis to establish the needs of the profession and of the nation. As an indication of the importance of the work of this committee, the Engineers' Council for Professional Development (ECPD), which is responsible for accrediting engineering curricula at all the engineering schools in the nation, recently announced that there will be no inspection of new curricula in engineering until adequate criteria are established, based in part on the findings of the ASEE Committee on Evaluation of Engineering Education.

It is evident that in planning a highway engineering education program, the limitations imposed by the engineering manpower situation must be considered. Further, consideration should be given to plans which will provide for the most effective use of the engineer's time, both as a student and later as a practicing engineer. Certain other adjustments in the professional program will no doubt be required if the accelerating needs in highway engineering and traffic engineering are to be met.

Historical Background

As a background for understanding the existing pattern of engineering education and its problems, it is well to review briefly some of the historical factors which have influenced the evolution of our current programs. For a more comprehensive treatment of the history of engineering education, reference is made to the notable papers of W. E. Wickenden[1] and F. T. Mavis[2], which papers provide the basis for the following summary.

The early engineers were trained by apprenticeship. Apprenticeship had

1. Wickenden, William E., "The Historical Development of Engineering Education", in Report of the Investigation of Engineering Education, 1923-1929. Pittsburg, Pa , University of Pittsburg, Office of the Secretary of the Society for the Promotion of Engineering Education, 1930. pp. 755-823 of Vol. 1.
2. Mavis, F. T. "History of Engineering Education", The Journal of Engineering Education, V. 43, No. 4, December 1952, pp. 214-221.

the advantage of training the engineer at the same time he was doing productive work. Under a good master it provided excellent training. The in-service training programs widely used today in industry and in large engineering organizations are a form of apprenticeship. The earlier apprenticeship practices, however, did not lend themselves to training large numbers of engineers. So, as the demand for engineers increased, engineering schools evolved. The first of these was organized in 1747 by J. R. Perronet, engineer to Louis XV of France. Perronet was given the job of building a system of national highways and, recognizing the importance of good technical training, organized his staff into a school which became the famous Ecole des Ponts et Chaussées in 1775. Not only has he been called the father of engineering education, but, as we who are concerned with highways note with interest, he fathered highway engineering education.

In the United States, by the time the American Society of Civil Engineers was founded in 1852, there were five engineering schools. In these schools emphasis was placed on a fairly broad education. Subjects in the basic sciences, such as mathematics, chemistry, physics and mechanics, were included, but only limited instruction was given in practical engineering.

The next four decades saw an increasing public interest in science and engineering as well as transitions in educational patterns, from general to practical and finally to somewhat of a balance between scientific and professional instruction. In 1862 the first Morrill Act resulted in the creation of many colleges of agriculture and "mechanic arts", publically supported through land grants. Many of these colleges developed programs of engineering instruction and placed special emphasis on instruction in practical engineering in shops and laboratories. By 1893, when the World Columbian Exposition was held in Chicago, engineering instruction was given in more than 100 schools in the United States; it was perhaps only a natural development then, that in connection with the Engineering Congress held in conjunction with the Exposition, the Society for the Promotion of Engineering Education was organized. While previous to this, the subject of engineering education had not lacked its appraisers and commentators, this Society became the vehicle for a number of later notable studies of engineering education.

By the turn of the century there had evolved the now familiar four-year undergraduate engineering curriculum, the first two years of which comprised largely studies of mathematics and physical science, and the last two years of which gave instruction of more or less professional character in the major field of specialization. It is of interest to realize that in spite of much investigation and examination of curricula, during the past 50 years, no profound change in philosophy or pattern of formal undergraduate engineering education has taken place.

Investigations Of Engineering Education

The first comprehensive study of engineering education was made by Dr. C. R. Mann during the period from 1914 to 1918 on behalf of the Joint Committee on Engineering Education and the Carnegie Foundation for the Advancement of Teaching. In the study of the curricula of 125 schools, the division of time was found to be 20 percent for the humanities and cultural subjects, 30 percent for mathematics and basic sciences, and 50 percent for technical subjects. The most significant result of Dr. Mann's study was based on a questionnaire sent to members of the national technical societies who were asked to express their opinions of the characteristics essential to an engineer's success. The returns from more than 7,000 members gave the fol-

lowing, in order of importance: (1) character, integrity, resourcefulness, initiative; (2) judgment, common sense, scientific attitude, perspective; (3) efficiency, thoroughness, accuracy, industry; (4) understanding of men, executive ability; (5) knowledge of fundamentals; (6) technique of practice and business.

This survey provided some unexpected results by placing the personal traits of character, initiative and common sense at the top of the list and technical competence at the bottom of the list. Dr. Mann concluded that this survey clearly indicated that "the professional demand identified the aim of engineering education with the aim of all education, namely, the development of men of character and of practical ability".

It is fair to conclude that the Marin report has had a large influence on thinking concerning engineering education. It discouraged over-specialization (at the undergraduate level) along technological lines in a period of spectacular scientific discoveries and great technological advances. It encouraged educators to hold to the ideals of a broad education in engineering in which some humanistic-social studies are integrated with the studies in science and technology. It set a pattern of investigation of the engineering profession and of engineering education which has been followed repeatedly since then, including the current investigation by the ASEE Committee on Evaluation of Engineering Education.

During the past 3 decades, engineering education and curricula in engineering have been the subject of almost continual study. The two-volume Wickenden-Hammond Report of the Investigation of Engineering Education, 1923-1934, constitutes a monumental treatise on every phase of engineering education in the United States and in Europe. This investigation contributed immeasurably toward the achievement of its objective "to develop, broaden and enrich Engineering Education".

It is significant that in all of the major investigations and studies of engineering education and engineering curricula conducted during the past three or four decades, there has been remarkable agreement of the findings. In general the following recommendations as given in the report of the SPEE Committee on Aims and Scope of Engineering curricula published in 1940, may be considered to be representative of the findings in all of the reports:

1. Engineering colleges serve diverse functions and prepare men for a wide range of technical, administrative, and executive responsibilities. Technical education should, therefore, be kept widely available and engineering colleges must continue to serve a correspondingly wide variety of purposes.

2. The present flexible arrangement of four-year undergraduate curricula followed by postgraduate work will better meet the needs served by engineering education than will longer undergraduate curricula of uniformly prescribed duration.

3. Undergraduate curricula should be made broader and more fundamental through increased emphasis on basic sciences and humanistic studies. A carefully planned stem of humanistic-social studies should be integrated with the science technology stem and studied concurrently.

4. Some of the advanced technical subject matter now included in undergraduate curricula should be transferred to the postgraduate period where it may be pursued with a rigor consistent with preparation for engineering specialization.

5. Aims of the scientific and technologic subjects should be:

a. Mastery of the fundamental scientific principles and a command of basic knowledge underlying the branch of engineering which the student is pursuing.
b. Thorough understanding of the engineering method and elementary competence in its application. This requires: comprehension of the interaction elements; ability to think straight, reasonable skill in making approximations; resourcefulness and originality; and understanding of the element of cost in engineering.
c. Ability to select the significant results of an engineering study and to present them clearly and precisely by verbal and graphic means.
d. Stimulation of a continuing interest in further professional development.

6. Aims of the humanistic-social studies should be:

a. An understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.
b. The ability to recognize and make a critical analysis of a problem involving social and economic elements.
c. The ability to organize thoughts logically and to express them clearly and convincingly in both spoken and written English.
d. An acquaintance with some of the masterpieces of literature and an understanding of their setting and influence upon civilization.
e. The development of moral, ethical, and social concepts essential to a satisfying personel philosophy, to a career consistent with the public welfare, and to sound professional attitude.
f. Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study.

The general objectives and scope of engineering education outlined above have been widely accepted by engineers in the profession and by engineering educators. One might expect that as a result of the general acceptance of the committee recommendations, engineering curricula would be standardized to a common pattern. The various investigating committees recognized this possibility and strongly advised against it. Each committee reaffirmed the need for careful experimentation with engineering education programs if progress is to be made. Also, it seems logical to expect each school to exercise a certain amount of individuality and initiative.

Thus, actually, while the general pattern of engineering education is the same at practically all engineering schools, there are wide differences in the details of the pattern at each school. This was clearly shown in the results of the study of civil engineering curricula at 114 engineering schools by the ASCE Committee on Engineering Education in a report published in the March, 1946, ASCE Proceedings.

The civil engineering content of the curricula at the 114 schools varied from 15 to 42 percent of the total units required for graduation; the mathematics content from 6 to 17 percent; the content of the physical sciences (physics, chemistry, geology, etc.), from 9 to 22 percent; the content in basic mechanics from 6 to 15 percent; and the content in humanistic-social studies from 7 to 28 percent.

In commenting on this study Dean Wessman, a member of the committee,

appropriately stated* that "Every one of the 114 schools will argue earnestly that they are doing a good job in engineering education. It is obviously very difficult to evaluate quantitatively any particular type of educational plan. Every school in the country has outstanding graduates who have made notable records in the practice of engineering and to whom the school will point with pride as evidence of the quality of its education."

Highway Engineering Education Program

The foregoing discussions of the important phases and significant trends in engineering education have been presented in considerable detail because we believe that they provide the basis for developing a sound over-all program in highway engineering education. Since highway engineering is one of the major fields in civil engineering the program in highway engineering should be coordinated and integrated with the civil engineering program. It follows also that education in highway engineering as well as engineering education in general should be responsive to the changing technology and needs of the times.

As was mentioned in the introduction of this paper, there are today unprecedented needs in highway engineering which will require expanded programs in highway engineering education. However, it should be obvious, from the trends in the pattern of undergraduate engineering education just described, that in spite of some variation in emphasis in the undergraduate curricula, little further professional specialization can be expected. Thus, if needs are to be met, some other approach than merely trying to introduce a new set of undergraduate courses is necessary.

In the discussion which follows, as an example of developing concepts concerning a broader approach to highway engineering education, an outline of the program at the University of California is given with our comments concerning its relation to over-all needs.

The University Of California Program

In 1947 the California State Legislature passed an act which provided for the establishment of an Institute of Transportation and Traffic Engineering at the University of California. The act provided that: "Said Institute shall carry on instruction and research related to the design, construction, operation and maintenance of highways, airports, and related facilities of public transportation.....to the extent deemed appropriate by the Regents of the University, the Institute....shall cooperate with the State Division of Highways and with other agencies charged with the responsibility for the design, construction, maintenance, and operation of highways, airports, and other related facilities for public transportation. In addition to, but not to the exclusion of, other appropriate subjects for research and study, the Institute shall give attention to the interrelated problems of highway design, traffic control, and highway safety."

In passing this act the legislature, was primarily concerned with establishing an Institute which would give attention to the requirements for training highway engineering personnel at the University and on the job, and to a continuing program of fundamental research aimed at the improvement and further development of highway transportation in California. It should be noted, however, that the Institute was established on the broad base of transportation

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* "Broadening of Curricula in Engineering Education" by Harold E. Wessman, M. ASCE. Civil Engineering V. 19, No. 4, April 1949, p. 35.

and that its activities were, therefore, not restricted to highway transportation but were intended to include all forms of transportation.

Organization of the Institute. -- The Institute of Transportation and Traffic Engineering functions on a statewide basis. Administratively, the Institute operates within the Departments of Engineering on the Berkeley and Los Angeles campuses. A director coordinates the activities of the two groups. There are two assistant directors, one on each campus, together with teaching, research and clerical staffs.

The Institute has the guidance of an Advisory Committee composed of outstanding individuals representing a cross-section of interests and viewpoints in the transportation field.

Institute staff members carry professional ratings such as research engineer, economist, psychologist, etc., with ranks corresponding to the several professional ranks. Staff members who teach may also carry academic ratings in the academic department or division in which they teach.

The Undergraduate Program. -- At the undergraduate level, the Institute cooperates with the Civil Engineering Division in offering the transportation option within the civil engineering curriculum to provide a selection of courses related to transportation engineering. The present program provides for a course in highway engineering required of all civil engineering students. The option courses which civil engineering students majoring in transportation may elect include route surveying, soil mechanics laboratory, asphalt laboratory, traffic engineering and railroad engineering. In addition civil engineering students may elect one or two courses from a wide variety of courses such as photogrametry, airphoto interpretation, economics of transportation, statistics, etc.

The use of undergraduate options in engineering curricula has been debated for many years. The arguments opposing options most commonly advanced are: (1) a four-year program does not allow sufficient time to introduce courses in specialized professional training; (2) the time devoted to options may be used more effectively in an expanded program of basic and applied sciences and socio-humanistic courses; (3) results of placement studies are cited which presume to show that up to 50 percent of the engineers trained in one field of engineering eventually find employment in another field of engineering or in a non-engineering field. It should be noted, however, that this tendency generally applies to engineers in industry and does not apply so generally to civil engineers since only a small percentage of graduate civil engineers are employed in industry.

Many of the large universities are continuing the use of options in civil engineering for the following reasons: (1) the professional or specialized engineering courses introduce the student to the engineering method of thought and analysis which has been a distinctive feature of engineering education over many decades; (2) these courses motivate the student and help him find himself, - in many cases they greatly contribute to the success of the student in college and after graduation; (3) the socio-humanistic courses at many engineering schools are poorly coordinated, are superficial and under these conditions are of doubtful value in attaining the desired objective of a broad and liberal engineering education; (4) the placement studies made by Wickenden in 1925 indicated that less than 30 percent of the graduate civil engineers obtained employment in another field of engineering or in non-engineering work. This was especially true in the placement of recent graduates where this percentage was less than 15% as was shown in the Wickenden report and also in a recent study at the University of California.

On the basis of the above arguments, it is evident that no clear cut decision in regard to options has been reached. Of course, it is true that the option plan is suitable for use only at the larger colleges and universities and that it is not practicable to use the option plan or an extensive elective system in engineering schools with a small civil engineering enrollment. Such a plan requires many sections and the cost of instruction per student would be prohibitive at the smaller schools.

An important question in the planning of undergraduate civil engineering curricula referred to earlier in this paper has to do with the effect which recent advances in science and technology, such as in nuclear physics, electronics, thermodynamics, optics, and engineering mechanics and materials, will have on the civil engineering curricula. In general, the widest application of the advances in science just referred to will be in fields of engineering other than civil engineering. The applications in civil engineering will at first be introduced in courses at the graduate level. In due time, however, certain applications will be assimilated in undergraduate courses replacing outmoded material. These adjustments are continually being made by alert instructors, just as they are being made by alert engineers in engineering practices.

In summarizing the curricular requirements for the undergraduate program from the viewpoint of the highway engineer, we recommend: (1) a basic four-year civil engineering program conforming to the general pattern of basic sciences, applied science, applied engineering and some socio-humanistic studies. The socio-humanistic studies should be integrated with the scientific and technologic subjects and studied concurrently; (2) a general course in highway engineering should be required of all civil engineering students and should consist of a 3-unit or 4-unit course for one semester, covering the fundamental principles, theories and practices in highway engineering, including such topics as highway finance, economics of highway location, highway capacity, geometric design, channelization, mechanics of traffic operations, highway drainage, grading operations, soil stabilization, design and construction of flexible and rigid pavements, and economic selection of pavements; (3) provision should be made through options and/or free electives for a limited amount of specialization in highway engineering by civil engineering students selecting transportation as their major subject.

The Graduate Program. -- The graduate program in highway engineering at the University of California is administered by the Division of Transportation Engineering which is the academic branch of the Institute. This program provides for the professional education of advanced engineering students in the field of transportation engineering. Various advanced engineering courses relating to the field of transportation are offered in the Divisions of Transportation Engineering, Civil Engineering, and Electrical Engineering. Candidates for advanced degrees are also expected to take work in one or more of the following areas of study: statistics, business administration, public administration, and city planning. A year of graduate work leads to the Master's degree.

Beginning with the next academic year a professional doctoral degree, Doctor of Engineering, will be obtainable in transportation engineering. This degree parallels the Ph.D. degree in scholastic standards and level of development, except that emphasis is placed on a mastery of subject matter of a chosen professional area. But there must be a demonstration of the power to use and synthesize relevant knowledge for the solution of broad problems of a professional engineering nature.

The graduate program provides professional training for a selected group of students with the required qualifications for advanced study and research. In general, the graduate courses are of a highly technical and specialized nature. The graduate program provides for a systemmatic study of a large body of technical knowledge in transportation not readily available to these students in any other form or place, such as through job experience or in an in-service training program. While it is desirable that graduate students have had realistic contact with practice, there is an increasing trend to take graduate work as a fifth year directly after graduation in a four-year program. It is a common experience today that once the graduate is established in a well paid job to his liking, he will not resign or request a leave of absence to return to a college or university for graduate work.

At the University of California certain graduate engineering courses are offered as evening and Saturday courses, thereby permitting practicing engineers living in the general vicinity of the University to enroll in these courses. The participation of practicing engineers in the graduate program has brought a fresh viewpoint to these courses and has been encouraged by the Institute and by the employers of these men. It has, however, only limited application in providing specialized training for practicing engineers.

An important feature of the graduate program is the close coordination of graduate instruction with the research program in which the teaching and research staff are engaged. Graduate study to be most effective should provide opportunity for training in the creative and practical phases of engineering design and development through the use of the project method. Individual and group research has been recognized as one of the most distinctive features of graduate work to give it the professional touch. Many outstanding contributions to engineering knowledge have been made through graduate student research and it is for this reason that it offers the greatest opportunity for doing productive work in the engineering education program.

The Research Program. -- In the above analysis, it was indicated that a successful graduate program requires a parallel program of research. In addition to serving its direct purposes of developing new knowledge and contributing to education, the research program yields two important by-products: (1) it serves to stimulate the thinking of staff members and (2) it provides a cooperative link between the University and other agencies.

The research activities in transportation engineering at the University of California are administered by the Institute of Transportation and Traffic Engineering. As a consequence of its affiliation with the University, the Institute may most appropriately attack problems which are fundamental in character, although a number of practical studies are conducted in cooperation with the California Division of Highways and other agencies.

Broadly classified, the Institute's present investigations, about 30 in number, fall under the headings: (1) highway planning and design, (2) highway economics, (3) traffic engineering, (4) motor-vehicle operation, (5) parking, (6) highway materials and structures, (7) automotive equipment, (8) highway illumination, (9) driver behavior and accidents, and (10) airport design.

The Extension Program. -- The extension program of the University of California is an extremely important phase of the Institute's statewide education activity. The entry of the Institute into extension activities was premised on a very evident need. The objectives of the extension program are to make available to personnel engaged in highway and other transportation fields in California, opportunities for extending their fundamental education, for reviewing and exchanging information, and for keeping abreast of new technical

developments.

The administrative means of carrying through an extension service or activity is provided by University Extension. The function of the Institute is to identify needs, devise programs to meet them, develop instructional materials, and provide instructors.

The identification of need is established largely by an extensive program of direct contact by the Institute's extension representative, as well as by other staff members, with the many individuals and agencies working in the transportation field. It is felt that only through close contact of this kind can the Institute program be adjusted to actual needs, and be coordinated with the activities of other agencies. Staff members visit with, and explore the problems of road officials of the counties, cities, and state highway districts. In addition, direct liaison is established with other appropriate state agencies, and numerous non-governmental groups.

The mediums for carrying out the extension program may be broadly classified as conferences, short courses, and regular extension courses. Conferences, ranging from 1/2-to 3-day meetings, are generally conducted in major population centers and are addressed to subjects of major interest to large numbers of California transportation men. They have ranged from a single presentation by some outstanding authority to a series of papers or discussions of a selected range of subjects. Short courses have been conducted (1) in various geographic areas of the state, including the remote areas, in the form of one or two evenings or weekend sessions dealing with some specific technical problem, and (2) in a single area each year, in the form of various 1-to 2-week full-time courses dealing with related problems. Regular extension courses are regarded as those meeting once a week, ordinarily in the evening, for several weeks, normally at a University Extension center.

Foremost among the conferences sponsored by the Institute is the Annual California Conference on Street and Highway Problems which draws its attendance, amounting to four or five hundred, from transportation men in all levels of government and in other related transportation occupations. It consists of a three-day program, with sessions devoted to specific subjects and interests, such as county road administration, urban arterial design, and construction and maintenance procedures.

Organizational In-Service Training

A recent survey by the U. S. Bureau of Public Roads indicated that there were 273,300 state and Federal employees on highway projects in 1950, of which 52,200 were state employees in engineering, supervisory and administrative positions. The State of California had 4,000 state employees on highway projects with 3,000 in the professional grade of Junior Engineer or higher. The turnover in personnel is very high, especially in the lower grades, where many are called into the military service. There is need for making a career in highway engineering as attractive as is reasonably possible, if the required personnel to carry out the expanding program for street and highway improvement are to be found and kept on the job.

Not only, then, is the need for well-trained and well-informed highway engineers greater than ever before, but a real need exists for continuously developing personnel on the job for increasingly effective discharge of current duties and to meet expanding responsibilities. A program of personnel development also gives promise of reducing turnover through stimulating employee interest and job attractiveness.

In recent years the Bureau of Public Roads and certain state highway departments have adopted student training programs which provide in-service summertime experience for civil engineering students on highway projects with good pay and other inducements. This provides an excellent means not only of training men but of attracting them after graduation to full-time engineering employment.

Another form of in-service training program used by the Bureau of Public Roads and some state highway departments to attract engineering graduates into highway engineering and to make best use of professional and sub-professional personnel work is by the use of a rotation plan whereby the young trainee is given a variety of experience within an allotted time. In the usual plan, the trainee is rotated in each phase of highway work such as road design, traffic, soils, construction, materials testing, and maintenance for a period of from 2 months to 6 months each. Some states try to rotate by types of tasks rather than by job, so that the trainee can get varied experience on a single project.

As was mentioned earlier, the present shortage of engineering graduates to meet the increasing demand for engineering services is almost certain to continue for many years to come. By properly coordinating the university extension type program with the rotation-type, in-service training program the efficiency and effectiveness of the work of the young engineers in highway departments can be greatly increased. Also the young engineer can more quickly find the job most suitable to his aptitudes. This general type of program, if supported by a reasonably competitive salary scale, opportunities for promotion, and other inducements, should attract promising young engineers into the highway field, promote progressive professional development and help alleviate the effects of the shortage of engineers.

However, to satisfy fully all the needs for highway engineering personnel, it seems almost certain that it will be necessary to develop training programs for sub-professional employees who can assist in survey work, routine work on road plans, inspection and similar sub-professional work. The men assigned to this type of work could be high school graduates or men who have only a year or two of college. It is not intended that these men should necessarily later qualify for work in the professional grades, although -- if they have the promise and the desire to do so, and if they qualify themselves by subsequent education or experience -- we may expect to find a significant fraction of them taking competitive examinations for positions in the professional grades.

Summary Comments

Even a cursory examination of our nationwide highway transportation problems indicates a present and continuing demand for a wide range of technologic and engineering services, including those of the very highest and broadest professional type. We have tried to indicate that the problem of supplying the required manpower -- both as to quantity and quality -- is crucial and complex. We have discussed the evolving patterns of formal engineering education in the United States, have pointed out how highway engineering education fits into this general picture, and have stated or implied how an "ideal" program is in some ways furthered, in others limited, by conditions as they exist. What attitude, then, can be taken toward the manpower and educational situation, and toward what course of action should we strive?

We believe, in the first place, that the approach must be a composite one.

No single, isolated program of action, such as a recruitment campaign, or specialized undergraduate training program, no matter how vigorous, will result in a real solution. Rather we are of the view that the training and education of highway personnel, the recruitment, retention and professional development of highway engineers, are interrelated problems which require the cooperative and coordinated attention of highway administrators and educators.

Secondly, we believe that post-graduate education must and should be a recognized and calculated part of professional development. The post-graduate work may, however, take a variety of forms, and thought must be given to where each form most effectively fits into the picture. For some individuals a year or two of graduate study may be advantageous. For others, a combination of job rotation and in-service training during the early period of employment may be preferable. For many others, a carefully planned program of study through extension services can be most valuable.

In view of a probable limit on the number of professional engineers available to serve the needs of the nation, and the consequent necessity for efficient use of the limited supply, consideration should be given to the segregation of tasks which can be performed by technician-operators who can be more rapidly trained for these specific occupations.

Apparently, educational developments such as we have described are taking shape in various parts of the United States. We can hope that they will be made continuously more effective by the cooperative effort of engineer-administrators and engineer-educators.

Finally, through it all, there must be an attitude, a philosphy, and an avenue which can lead to the development of broad-gaged leaders of the highway engineering profession, who can eventually take their places as top administrators. This, of course, is an attitude which must extend throughout the profession, and to which college education can only contribute the incentive and initial drive.

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